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ABSTRACT

This booklet introduces an environmental curriculum for use in a variety of elementary subjects. The lesson plans provide an integrated approach to incorporating Great Lakes environmental issues into the subjects of history, social studies, and environmental sciences. Each of these sections contains background information, discussion points, and a variety of hands-on activities designed to illustrate the major points of each lesson. A map of the Great Lakes is provided for photocopying and can be used with the discussion points and activities. Topics include the history of the Great Lakes, shipwrecks, water use, acid rain, air pollution, lake clean-up, groundwater, surface runoff, industrial runoff, and sediment pollution. General facts about each of the Great Lakes are listed. (KR)

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Great Minds?

Great Lakes!

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Don't Miss the Boat with Environmental Education

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Introduction

Great Minds? Great Lakes! has been developed by the United States Environmental Protection Agency's Great Lakes National Program Office to introduce environmental curriculum for use in a variety of elementary subjects. Inspired by U.S. EPA's environmental research vessel named *Lake Guardian* by elementary schools in the Great Lakes Basin, this publication is dedicated to helping students learn more about the environment and about the Great Lakes.

The lesson plans in this book provide an integrated approach to incorporating Great Lakes environmental issues into the subjects of history, social studies, and science. These lessons are just a sampling of the educational material contained in *Great Lakes in My World*—a more comprehensive curriculum developed by the Lake Michigan Federation and the Great Lakes National Program Office.

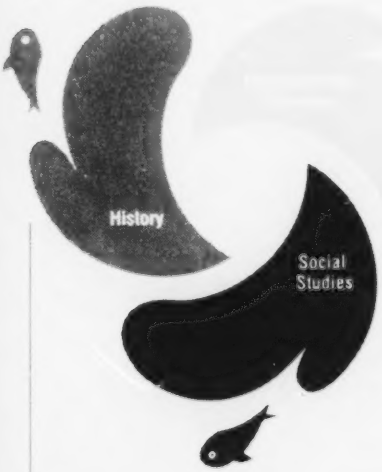
Use the material in this book to introduce your students to the importance of environmental issues and to see how all of us are part of the Great Lakes Basin ecosystem. Share the lore of the Lakes with your students through history lessons and stories about famous shipwrecks. Teach your students about Canada and the United States through social studies lessons, and help them learn how both countries are responsible for protecting the Lakes. For example, explore the difficulties of solving international problems such as acid rain. Finally, follow the journey of the *Lake Guardian* as it travels from lake to lake introducing your students to some of the more compelling environmental problems affecting the Great Lakes today.

Once you have used *Great Minds? Great Lakes!*, move on to the expanded and more detailed lessons offered in *Great Lakes in My World*, available in the fall of 1990. For more information regarding *Great Lakes in My World*, contact The Lake Michigan Federation, 59 E. Van Buren, Suite 2215, Chicago, Illinois 60605, (312) 939-0838.

How to Use this Book

Great Minds? Great Lakes! is divided into three subject areas: History, Social Studies, and Environmental Sciences. Each section contains background information, discussion points, and a variety of hands-on activities designed to illustrate the major points of each lesson. In the back of the book, a map of the Great Lakes is provided for photocopying, and use with discussion points and activities. A bibliography and reference page tells you where you can find more information on all the topics presented throughout the book.

As the figure below indicates, the lesson plans in each section are designed to interrelate with



each other to demonstrate how environmental issues can not be isolated from other issues such as population and industry. Information in one lesson plan can be used easily with another. For instance, use the lessons in the history section to demonstrate the link between the settlements of the early explorers and the growth of modern metropolitan areas. Use social studies lessons to understand how these metropolitan areas use and economically depend on the Great Lakes. Finally, demonstrate the link between the use of the Great Lakes and environmental problems discussed in "The Journey of *Lake Guardian*."

About the *Lake Guardian* Research Boat

The *Lake Guardian* was converted to a research vessel from an offshore supply vessel in 1990 by the Great Lakes National Program Office and was named by the children of 10,000 elementary schools in the Great Lakes Basin. The students voted on names contributed by environmental interest groups in the Great Lakes area, and the winning name was *Lake Guardian*.

Lake Guardian is used to conduct in-depth studies of water quality in the Great Lakes Basin by collecting samples of water, sediment, fish, and other biological matter. By monitoring toxic chemicals and other pollutants in this fragile freshwater world, scientists study the effects of pollutants and assess various cleanup programs underway in the Great Lakes Basin using samples and analysis from the *Lake Guardian*.

About the Great Lakes National Program Office

The Great Lakes National Program Office (GLNPO) was established in 1977 as a special arm of the U.S. EPA dedicated to Great Lakes environmental issues. GLNPO was started to meet the obligations of the United States under the Great Lakes Water Quality Agreement with Canada. GLNPO is the first U.S. EPA office that is solely devoted to a distinct ecosystem such as the Great Lakes Basin. GLNPO has an extensive surveillance and monitoring program which measures conditions in the Lakes and traces the sources of pollutants.

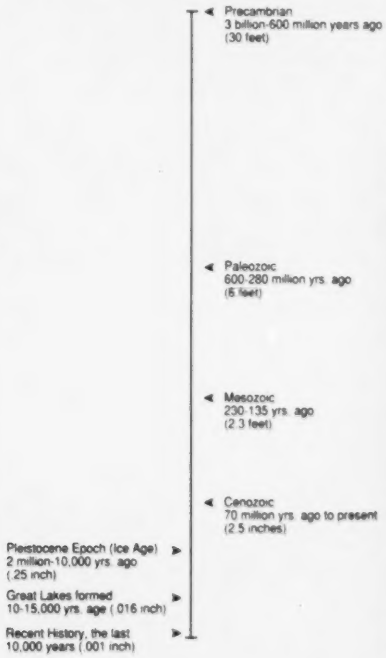
To keep track of pollutants entering the Lakes, GLNPO operates the Great Lakes Atmospheric Deposition Network to measure pollutants from the atmosphere, while states track pollutants in tributaries entering the Lakes. GLNPO works closely with various federal agencies, eight Great Lakes states, and comparable Canadian agencies to share and interpret data. In addition, GLNPO coordinates U.S. EPA's implementation of regulatory actions and activities to influence state programs in the Great Lakes Basin.

History

Where did the Great Lakes Come From?

The story begins about three billion years ago. This lesson condenses and describes millions of years of geologic history to help students appreciate how long it took to form the Great Lakes and the origin of its many treasures, including rich mineral deposits.

During the Precambrian Era, which started about 3 billion years ago and ended 600 million years ago, a great deal of volcanic activity occurred. This action and sedimentary deposits were the source of the rich mineral deposits found in this region. During the Precambrian Era, the only types of life existing on the Earth were algae, fungi, and bacteria.



After billions of years of volcanic activity, central North America was flooded several times during the Paleozoic Era, which lasted more than 350,000 million years. The flooding brought different soil materials, such as mud, clay, and sand, as well as various forms of sea life, to the Great Lakes Basin area. During the Paleozoic Era, the first fish, insects, reptiles, conifers, and tree ferns appeared on Earth. The Mesozoic Era followed on the heels of the Paleozoic Era. It lasted over 167 million years and brought dinosaurs, mastodons, birds, mammals, gymnosperms, and flowering plants to the Lakes area. The decomposition and accumulation of the remains of plants and animals during this Era added further to the mineral resources of the Great Lakes area.

The Era we are in now, the Cenozoic Era, started 70 million years ago. Eras are divided into epochs, and scientists now believe that the Great Lakes got their start prior to the Pleistocene Epoch, also known as the Ice Age, which occurred in North America about 10,000 years to 15,000 years ago. The region where the Lakes are now originally was carved out before the Ice Age by an ancient river system that emptied into the Hudson Bay or St. Lawrence River Valley.

During the Ice Age, glaciers covered central North America as far south as Kansas and Nebraska, as far east as New York

Discussion:

1) *Discuss what a glacier is, how it moves, how it can change the geography of the land.*

2) *On a map, point out where the glaciers covered the Great Lakes area. Have the students ever seen ice that big? Explain that glaciers still exist today in many parts of the world, e.g., Glacier National Park in Montana, Sierra Nevada Mountain Range in Nevada, and Columbia Ice Fields in the Canadian Rockies near Jasper, Canada.*

Activities

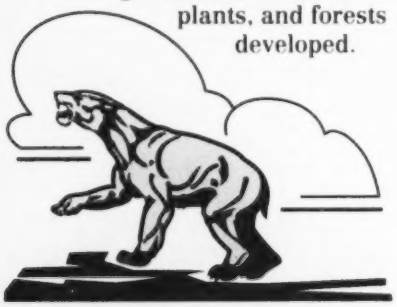
1) **Time Line:**

Materials: 30-foot piece of string or clothesline and at least six clothespins.

Procedure: Have two students hold up the string as a time line across the front of the classroom. Depending on the grade level, either have the students write down the names and characteristics of each era, or have the students draw a picture of the activities that occurred. Clip students' work to the appropriate time period on the string. (Use the timeline diagram for reference) Optional: research animals that lived during the time periods and cut out animal tracks of each type of animal, including human beings (they can trace their own feet). Lay the timeline on the floor and lay the tracks down next to it so the footprints walk through time at the appropriate eras. As the Ice Age and recent history time periods converge, students will be able to visualize how plants, animals, and human beings are recent history relative to the evolution of the Earth.

2) Using boxes, create "scenes" from different periods of the Great Lakes' geologic history, showing formations and animals unique to each phase of their development.

and as far west as the northern West Coast. In some places, the glaciers were over 6,500 feet thick, almost a mile-and-a-quarter high. Through the sheer weight of the ice, coupled with the varying hardness of the rocks beneath it, the glaciers tore up the river terrain, creating natural dams and dikes that obstructed the drainage of the ancient river system. As the glacier receded from North America, the Great Lakes began to form from the melting receding glacial water which had enlarged the original river basin. During the Ice Age, modern humans, saber tooth tigers, mammoths, and numerous other animals began to roam the Earth. In addition, the first grasslands, herbaceous plants, and forests developed.



Great Lakes People

For a variety of reasons, the Great Lakes have attracted many different kinds of people from all over the world. From Native Americans to European immigrants, these people contribute to its diversity and cultural richness. This lesson introduces students to the people of the Great Lakes Basin.

About 10,000 years ago, around the time that the glacier receded, the first inhabitants of the Great Lakes area appeared. It is believed that these Native Americans came from South America or across the land bridge once connecting the continents of North America and Asia in Alaska. Tribes of Native Americans peopled the shores, among them the Iroquois, Allumettes, Chippewas, Hurons, Ottawas, Senecas, Mohawks, Eries, and Ojibways. Many cities take their names from the tribes or great chiefs of these tribes, including Ottawa, Canada; Pontiac, Michigan; and Erie, Pennsylvania. Lake Huron was named directly for the Huron Indians. Other present-day cities were once Indian villages, including Quebec, Canada, which was once Stadacona; and Montreal, Canada, which was Hochelaga.

In Europe, two events increased curiosity about the so-called New World: voyages by Norsemen in the twelfth to fourteenth centuries and the voyage to America by Christopher Columbus in the fifteenth century. Artifacts such as a Viking sword, axe and shield found in Ontario and southwestern Minnesota suggest that the Vikings and Norsemen may have reached the North American continent as far inland as Minnesota via the Hudson Bay.

In the 1500s and 1600s, the French were the primary explorers and settlers in and around the Great Lakes. Less than 200 years after Norsemen reached the Great Lakes, French explorers and missionaries began to arrive. Over a period of time, they constructed forts along the Great Lakes all the way to Kingston, Ontario, where Fort Frontenac was located.

The British were active, too, constructing Fort Oswego on Lake Ontario's south shore in the early 1700s. The British had already colonized the New England states and parts of Pennsylvania. Steady migration by the British into French-dominated territory around the Great Lakes led to war between the two nations over the fur trade. The first African Americans arrived in the Great Lakes area in the late 1700s, when Jean Baptiste Pointe DuSable, a trapper, built a cabin in the Chicago area. African Americans came in greater numbers in the late 1800s.

During the 1800s, there was a mass influx of other ethnic groups from Europe. They came to the New World in search of freedom and prosperity. In all, more than 21 different nationalities settled in the Great Lakes area. Scandinavians again were among the first to arrive. Norwegians founded the first permanent colony on the Fox River in Illinois, and Swedes settled at Pine Lake, Wisconsin, west of Milwaukee. Belgians also came, and the largest population of Belgians in the United States are now in Door County, Wisconsin. The Irish represented the largest immigrant group in Canada. The first group of Finns settled on the upper peninsula of Michigan and worked in the copper mines there. They also peopled the areas around Duluth, Minnesota, working in the open-pit mines of the Vermilion and Mesabi ranges. Germans flocked to the Great

Discussion:

1) *Ask the students to talk about where their families are from. Why did their families originally move to the Great Lakes Basin?*

2) *Locate interesting names of towns and cities on a map of the Great Lakes. Determine the origin of the name or have the class write to the city's Chamber of Commerce for further historical information.*

Lakes area, particularly in Sandusky, Ohio, on Lake Erie and in Milwaukee, Wisconsin.

Also among the immigrants to the Great Lakes Basin were the Canadians, French-Canadians, Russians, Czechs, Greeks, Turks, Persians and Spaniards, Welshmen, Scotsmen, and Dutch. Immigrants from Mexico, Puerto Rico, and other Central American countries came at the turn of the century, with significant migration occuring during World War I.

Activities

1) **Have the students research the Native American and European people who first settled in the Great Lake Region. Locate early settlements on the map.**

2) **As a class, research and dress up as early explorers of the Great Lakes region and describe their experiences. Have the students write a make-believe journal entry of an explorer's adventures.**

3) **Have the class research the history of your town. Write to a local historical group or invite a long-time resident to share his or her memories of the town's history with the class.**

Shipwrecks

A sailor's life journeying the five Great Lakes sounds romantic, but not all the journeys have been smooth sailing. The Great Lakes have seen their share of shipwrecks over the years.

Explorer Robert de LaSalle's ship, *The Griffin*, one of the first large ships ever to sail the Great Lakes, was launched in 1679 and carried a load of furs out of Green Bay on its maiden voyage. She was never seen again and no splinter ever washed ashore. *The Griffin* leads the long parade of ghost ships that provide us with the great mysteries of the Great Lakes.

In 1871 alone, 1,167 disasters were recorded. In the two decades between 1878 and 1898, the United States Commissioner of Navigation reported 5,999 vessels wrecked on the Great Lakes and 1,093 of these were total losses. 1905 was a particularly bad year on the Lakes with 271 vessels damaged, 54 of which were lost through the stress of weather.

Whereas luck and intuition were the tools available to early skippers, today's captains have the finest and most sophisticated navigational aids available. Ships are equipped with weather warning systems, radios, direction finders, and depthometers. Careful study of previous shipwrecks has taught us how to improve ship construction and methods of navigation.

Despite all that modern technology can offer, surviving a Great Lakes storm is still a challenge. The storms of the Great Lakes have been compared with a "witches brew," and a "devil's harvest." Storms can explode across hundreds of miles of open water with little or no warning. Storms on the Great Lakes often can be more difficult to navigate than ocean storms. Waves on the Great Lakes jump and strike quickly compared to the lethargic rolling and swelling of ocean waves.

Just as there are comparisons to be made between ocean storms and lake storms, there are differences in the way each of the Great Lakes reacts in a storm. Most veteran captains and crews find Lake Erie the least agreeable in either fair or foul weather because of its shallow depth and muddy bottom.

Lake Superior is a favorite among mariners because its large size affords the greatest amount of room for maneuvering during a storm. However, it too poses a challenge to navigate with its rocky coastline, cold temperatures (40 degrees in summer or winter), and huge waves that develop because of the Lakes' depth. An ancient Chippewa legend warns that Superior "never gives up its dead."

Lake Michigan commands the greatest respect among seafarers for several reasons. Prevailing winds sweep its length

and the currents caused by wind shifts around the Straits of Mackinac cause it to be the trickiest of the Lakes to keep on course. It also has a scarcity of natural harbors and human-made places of refuge.

Activities:

1) **Have students research a Great Lakes shipwreck and tell the story to the class (see back cover for resources).**
2) **Contact a maritime museum in your state and ask what underwater archeology is currently being done in the Great Lake nearest you.**

Discussion:

1) ***Talk about the different navigational challenges posed by each Great Lake. The information mentions that previous shipwrecks lead to the development of further safety precautions. Discuss with the students what might be learned from shipwrecks. How can shipwrecks tell us about the way people lived long ago and about the history of shipping?***
2) ***Discuss what inventions and advancements in weather prediction have made navigation on the Great Lakes safer.***

The Fate of the Christmas Tree Ship

It was late November and the sights and sounds of the holiday season were creeping into the bustling city of Chicago. Each year, the arrival of the creaking old three-masted schooner *Rouse Simmons* served as a signal for the beginning of the Christmas season. The schooner always ended her shipping season by bringing to Chicago a large and profitable cargo of Christmas trees.

Along with the annual tree buyers, peg-legged and bearded Claud Winters eagerly awaited the arrival of the *Rouse Simmons*. Claud and Captain Schunemann, owner and master of the ship, had an unusual bond. Although their lives were quite different, they seemed to understand and sympathize with each other.

Claud was soft-hearted under his rough outer appearance. As a child he had lost a leg under a boxcar, so he couldn't handle the demands of being a seafarer. Claud admired the Captain as a fearless sailor and a smart ship operator. In the great storm of 1889 the *Rouse Simmons* was the only sailing ship that was not severely damaged or lost.

The Captain was legendary for his stinginess and stubbornness in working with anyone who might cut into his profit. Claud would have enjoyed the thrill and adventure of a sailor's life. The Captain must have understood this about Claud because he was unusually generous to his stocky peg-legged friend. Once the Captain gave Claud a silver dollar saying, "Always keep this and you'll never be broke." Whenever they met, Claud would show him the coin and say, "Here it is Cap...still as good as new and still a yearnin' to be spent."

On the morning of November 27, 1912, Claud stomped onto the Clark Street wharf to await the early morning arrival of the *Rouse Simmons*. Claud had hired a group of men to unload the fragrant pine and balsam trees. When the ship was nowhere to be seen, Claud was sure the Captain was floating offshore waiting for the fog to lift so he wouldn't have to pay charges for a tug to bring him in. But by 4:00 PM many of Claud's hired companions had tired of waiting and left. Claud himself was feeling tired, discouraged and hungry. Many busy tugs had come upriver, but nowhere on the horizon could he see the sails or masthead lamps of the *Rouse Simmons*.

The year 1912 had been a devastating one for Great Lakes shippers. The worst snow storm in a century had blasted the lakes for four days in early November, destroying 10 large freighters and littering the shoreline with debris. Four hundred seamen were lost in those four disastrous days.

Meanwhile Captain Schunemann was realizing he could turn a disaster into a fortune. Snow had buried tree farms in Michigan and Wisconsin. Chicago tree dealers were desperate for trees. Captain Schunemann was happy to deliver! At Thompson Harbor just southwest of Manistique, Michigan trees were being crammed into every available space on the *Rouse Simmons*. Well into the evening, the Captain had more bundles of trees tied on board the deck, row upon row. The schooner sagged under the weight of her fragrant cargo. He expected this could be the most profitable run he had ever made.

Despite stormy weather, the *Rouse Simmons* set sail at noon on November 25, 1912. The schooner *Dutch Boy* was seeking shelter when its captain spied the *Rouse Simmons* off his bow. He exclaimed above the howling wind, "Mother of God, look! That

crazy Dutchman's going out in this, and him with every inch of canvas up!"

As the *Rouse Simmons* swung west southwest on course towards Chicago, she was caught in deadly winds of 60 miles per hour. Every part of the ship creaked, moaned, and shrieked in the howling gale. Some time during the night two sailors were sent to check the lashings. A tremendous wave swept them, along with many of the bundled trees and a small boat, into the raging seas. With less weight on board, Captain Schunemann and his first mate were able to maneuver the vessel toward shelter at Bailey's Harbor.

As fate would have it, the violent wind changed suddenly, producing a furious snowstorm and an incredible drop in temperature. A thick blanket of ice quickly thickened as the unrelenting waves pounded the ship. The situation of the *Rouse Simmons* was becoming more desperate each moment. Battered hatch covers could no longer prevent water from entering the hold where it quickly turned into ice on the trees.

From the station tower at Sturgeon Bay, Wisconsin, men of the old United States Lifesaving Service sighted the *Rouse Simmons* flying distress signals as she continued to move low in the water, driven along by the force of the gale. A rescue team 25 miles to the south launched a surfboat in an attempt to intercept the suffering schooner. Visibility was difficult and a two hour search was unsuccessful. But suddenly there was a break in the snowstorm and the pitiful ship was sighted. She was barely afloat and resembled a mass of ice. Rescuers desperately moved full steam ahead as blinding snow again made it impossible to see the schooner. The *Rouse Simmons* vanished from sight and was never seen again.

Meanwhile, Claud Winters continued to believe that the *Rouse Simmons* would arrive even after a note was found in a bottle on the beach in Sheboygan, Wisconsin. It said, "Friday... everybody goodbye. I guess we are all through. During the night the small boat was washed overboard. Leaking bad. Ingvald and Steve lost too. God help us. Herman Schunemann." Chicago suffered from a shortage of Christmas trees that year.

That Christmas Eve, Claud made his daily trip to the dock. He stood in the falling snow waiting for the *Rouse Simmons* to arrive. The next morning a policeman found him blanketed with snow. Believing to the end that the Captain would come through, Claud's sad life was ended. As the policeman picked up his lifeless body, a silver dollar fell from his frozen fingers and rolled into a crack in the dock, landing in the icy black water below.

It was another 10 years before evidence of the *Rouse Simmons* was discovered. Captain Herman Schunemann's wallet was found among the fish caught in the nets of a Wisconsin fisherman.

Discussion:

1) *Discuss Claud Winters and Captain Herman Schunemann's personalities, interests, and appearance.*
2) *Talk about what kind of person would choose the life of a seaman in the early part of the century.*

Activities:

1) Have the students trace the route of the *Rouse Simmons* on the Great Lakes map.
2) Have the students write a diary entry that Claud Winters might have written after one of the evenings he spent at the dock waiting for the *Rouse Simmons* to arrive, or have them write a message one of the crew of the *Rouse Simmons* might have written and put into a bottle in hopes that it would eventually reach his family.
3) Assuming that the *Rouse Simmons* had made it safely to Chicago, use the information below to make up math problems appropriate to the level of your class:

Number of trees loaded onto the ship:	1,000
Number of trees washed overboard in the storm:	300
Price Captain Schunemann paid for the trees:	$.25/each
Price of trees when sold in Chicago:	$.75/each

For older students, discuss gross and net profits, taking into consideration the cost of shipping the trees and the cost of the lost trees.

Social Studies

Where Would We Be Without the Great Lakes?

The Great Lakes are part of our daily lives. They provide us with fresh drinking water; industries and jobs including agriculture, fisheries, manufacturing, shipping, and tourism; and beautiful shorelines and parks. This section explores how we depend on the Lakes and the many ways we use them.

The Great Lakes provide us with fresh water for just about any kind of activity you can imagine. Today, there are approximately 37 million people living in the Great Lakes Basin and more than 26 million of these people rely on the Great Lakes for their drinking water. Most of the original settlements which grew into cities were established near tributaries that provided a supply of fresh water for domestic and industrial use.

How much water do these 26 million people use in a day, a year, their lifetime? The Great Lakes contain about 5,500 cubic miles of water. If a person took 3 baths a day, it would take over 110 billion years to use all the water in the Great Lakes! If all 26 million people took 3 baths a day, it still would take 4,254 years to use all the water in the Lakes.

Many people don't realize it, but resources in the Great Lakes Basin are responsible for the quality of our lives. So much of our lives depend on the Great Lakes' rich farmland, abundant fish, water power, transportation, and natural beauty.

How Much Water Is Used...?

In the average residence per year:	**107,000 gallons**
By an average person daily:	**168 gallons**
To flush a toilet:	**5-7 gallons**
To take a shower:	**25-50 gallons**
To take a bath:	**50 gallons**
To brush your teeth (with water running):	**2 gallons**
To wash dishes by hand:	**20 gallons**
To run a dishwasher:	**15-25 gallons per cycle**
To wash clothes in a washing machine:	**35 gallons per cycle**
To water your lawn:	**35 gallons per half acre**

6

Discussion:

1) *Discuss how students and their families use water in their daily lives and explore how important water is as a natural resource.*

2) *Discuss what would happen if fresh water was not readily available. Talk about ways drinking water is wasted and how it can be conserved.*

3) *Using the information on water use, calculate how much water the students and their families use each day. Have students measure the amount of water they use to brush their teeth once, then calculate how much water they use a week or a month.*

Within the 201,000 square miles of the Great Lakes Basin, 67,000 square miles are devoted to agriculture—an area larger than each of the bordering states except Minnesota. The main agricultural products produced in the region today are wheat, corn, soybeans, barley, and oats. Grapes are grown in the Lake Ontario region for wine-making in New York. The Lake Michigan area contains the most farmland of all the Great Lakes and is a leading grower of fruits and vegetables. The State of Wisconsin is known for its cheeses and other milk-products. The Lake Erie region leads the Great Lakes in the raising of pigs, sheep, soybeans, wheat, and chicken corn. The Lake Huron Basin is the world's biggest producer of navy beans, and the Lake Supe-

rior region is an active forest products producer.

Great Lakes fish are an important source of food for people and hundreds of species of animals and birds. The average annual commercial fishing catch is approximately 110 million pounds. Major species caught in the Great Lakes include whitefish, yellow perch, lake trout, salmon, walleye, lake herring, rainbow smelt, chubs, white bass, brown bullhead, and carp. One of the most prosperous fishing areas is Lake Erie, where the walleye pike fishery is widely considered the best in the world. In Canada, the Lake Erie fishery represents nearly two-thirds of the country's total Great Lakes harvest.

Shipping has been responsible for the development of the entire Great Lakes Region. The Great Lakes and their interconnecting channels have provided a natural transportation system for exploration and settlers, and trade and transport of goods—particularly mineral resources and agricultural products. Boom towns have come and gone as shipping enabled natural resources to be reached and transported, and today shipping continues to be a major industry on the Lakes. Iron ore from the Lake Superior area is shipped to mills in Chicago, Cleveland, and Gary to be made into steel. This steel is then shipped to Detroit automakers. Among the other products transported on the Lakes are coal, limestone, grain, newsprint, and cement. In 1959, completion of the St. Lawrence Seaway drastically changed the Great Lakes shipping industry by expanding it to include international transport.

Many manufacturing industries are attracted to the Great Lakes area because of the advantages of being near a water source which provides cheap electricity and convenient transportation routes. Major manufacturing industries in the Great Lakes region include steel, paper, chemicals, and automobiles. Thirty-six percent of United States automobiles and 38% of Canadian automobiles are produced in the Basin. The steel industry is concentrated at the southern end of Lake Michigan, and in Detroit, Cleveland, and Lorain, Ohio. Paper mills are located primarily in the upper Lakes, with a large concentration of mills along the Fox River that feeds into Green Bay on Lake Michigan. Chemical manufacturers are on the Niagara River, the Saginaw Bay in Lake Huron, and in Sarnia, Ontario.

Tourism and recreation also are major industries in the Great Lakes Basin. For example, in Ottawa County, Ohio, the regular population of 40,000 increases to about 250,000 on weekends as tourists come to enjoy the sights. In many areas of the Basin, small unprofitable marinas have been turned into multimillion dollar complexes with stores, restaurants, and swimming pools. Sport fishing also is a major component of the recreation industry. The sale of licenses, equipment, and boat rentals generates hundreds of millions of dollars every year. Charter fleets and a large fish stocking program have been developed to fuel the industry. Over 60 million people each year visit the 98 state parks, 39 provincial parks, and 12 national parks on the United States and Canadian Great Lakes shores.

When we consider the benefits we gain from all of these industries in the Great Lakes Basin, it is important to remember that each of these industries have environmental consequences.

Activities:

1) On a map, fill in the major cities mentioned and trace the channels between Lakes which allow ships to travel between Lakes. Draw in symbols or figures representing different types of industries located around the Lakes.

2)) Have each student draw a picture of his or her favorite Great Lakes recreational activity. Make a collage of all the pictures.

Who Governs the Great Lakes?

The Great Lakes are so big that their shores span the boundaries of eight states and two Canadian provinces. With so many government bodies involved, preservation of the Great Lakes requires cooperation and team work. This section will explore the necessity for governments and people to work together to solve the environmental problems facing the Great Lakes region.

Discussion:

1) *Imagine what it would have been like living in the Great Lakes area before trains, cars, and airplanes were invented. Why were the Great Lakes important to the settlers?*

2) *Discuss the types and functions of ships used on the Great Lakes such as freighters, commercial fishing ships, and pleasure crafts. Ask students what types of ships they have seen on the Lakes.*

3) *Discuss why the Great Lakes are important to farming. How does the water get from the Lakes to the farms? What would happen if the water in the Lakes were so polluted it could not be used for farming?*

4) *Talk about what would happen if there were no fish in the Great Lakes. With no fish to eat insects, what would happen to the number of insects?*

5) *Ask the students what kind of fun activities they can do around the Great Lakes. Have they visited any state or national parks in the Great Lakes Basin? Why is it important to have parks along the border of the Great Lakes? (minimizes shoreline development)*

Because the United States and Canada share the Great Lakes as a border, many governments are involved with environmental problems in the Great Lakes Basin: on a federal level, the U.S. Environmental Protection Agency and Environment Canada; eight state governments (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin); and two Canadian provinces (Ontario and Quebec). Having both Canada and the United States involved presents the unique situation of two nations responsible for managing and protecting a natural resource.

To officially agree on how to protect the Great Lakes, the United States and Canada signed a treaty in 1909 called the Boundary Water Treaty. The treaty declared that neither Canada nor the United States has the right to pollute the resources of its neighbor. It also said that both countries have equal rights to the use of waterways that cross the international border of the Lakes. Despite the agreements made in the treaty, pollution problems began to mount, and by the early 1970s, the two countries had to reconsider the Boundary Water Treaty.

The two countries decided to make a more specific commitment to restoring and maintaining the environmental health of the Great Lakes Basin. The agreement, called the Great Lakes Water Quality Agreement, was signed in 1972 and created a bi-national commission that would be responsible for reducing pollution in the Great Lakes and developing specific plans for cleaning up many of the pollution problems in the Basin. The commission is referred to as the International Joint Commission.

Making progress on the problems that affect the Great Lakes is not easy. This is because the problems are not simple ones and because every proposal has ramifications that are both good and bad. For example, an environmental protection proposal that limits industrial growth may help prevent further pollution of the Great Lakes, but it may have negative effects on the economy and the availability of jobs.

Discussion:

1) *Talk about other natural resources we share with Canada and other countries such as air, oceans, and wildlife.*

2) *Ask students if they know who is in charge of making decisions about how to clean up pollution on the Great Lakes. Discuss how we can influence our governments to work hard on ways to protect the Lakes.*

3) *Talk about jobs students could have in the future that will contribute to protecting the Lakes (engineer, teacher, scientist, zoologist, biologist, politician).*

4) *Brainstorm ways that working cooperatively with a partner or group can be beneficial in solving problems.*

Acid Rain: A Shared Problem

When talking about acid rain, the old adage applies—what goes up must come down. This section explores acid rain, an example of a difficult environmental issue facing the United States and Canada. By focusing on this complex environmental concern, the lesson reveals why it is so important for governments to work together and be aware of how their actions affect the quality of life of others.

Acid rain is rain, snow, hail, fog, dust, or soot containing high levels of acid. Pollutants that are transferred from the air into the Lakes are responsible for harming the quality of the water in the Lakes, as well as the health of the plants and animals that call the Great Lakes home. But acid rain isn't just a regional problem; it is a global problem and there is little worldwide agreement on how to tackle it. Neither the United States nor Canada can combat acid rain alone. It is carried across national frontiers and often affects distant places more strongly than where it is produced. Solving the acid rain problem requires an understanding of the consequences of our actions in the United States and Canada, and the necessity of cooperating in the search for a solution.

With the issue of acid rain, attention is drawn to the Great Lakes Basin. This is because many "smokestack" industries are located in and near the Basin, and many people believe that the pollution from these industries contributes to the acid rain problem in Ontario, eastern Canada and northeastern United States. Many Canadians get upset with the United States because so much of the pollution coming from industry in the United States blows with the wind, sometimes ending up in Canada.

There are no simple solutions to this problem. Cost, economics, and available technologies are all issues at stake. Most leaders anticipate that stopping acid rain will be costly. Many dollars will have to be spent to change the way fuels are burned and how other industrial processes are used to make the goods and services on which our society depends. Because so much of the industry is located on the United States side of the Lakes, some Great Lakes states are nervous that they will be responsible for much of the cost.

Long term solutions to the acid rain problem include instituting strict air quality legislation, developing technologies to

Activities:

1) On the Great Lakes map provided, have students identify and color in the United States, Canada, the Great Lakes, and states and provinces that border the Great Lakes. Using a different color, trace the United States and Canadian border. Have the students ever crossed any borders? Could they tell they were entering another country?

2) **Conflict Resolution**

Divide the class into groups representing each state and province. Have each group make a plan for protecting the Great Lakes. All state groups should meet to share their ideas and develop one overall plan for the United States. Do the same with the Canadian provinces. Finally, one representative is chosen from each country to work out an international agreement for protecting the Great Lakes. The agreement has to be acceptable to both countries. If there are disagreements, ask the students to explore creative ways of solving conflicts. This activity is easily adapted to different grade levels. For lower grades, students could explore plans for keeping the school yard clean. Higher grade levels could expand the students roles to represent various interests and industries affected by such agreements.

help fuels burn more cleanly, and filtering gases before they enter the atmosphere. Individuals can contribute to solving the acid rain problem by instituting recycling programs, using public transportation, and turning off appliances to cut down on energy consumption.

About Acid Rain

The majority of acid rain results from fossil fuels such as coal, oil, and natural gases burned in industry, electrical power plants, and motor vehicles. Once in the atmosphere, these pollutants combine with moisture and interact with sunlight to form sulfuric acid and nitric acid. Tall factory smoke stacks discharge pollutants high into the atmosphere where winds carry the acids for hundreds of miles. Eventually the acids fall back to the earth in the form of rain, snow, or dust. Factors influencing how far acid rain travels include wind speed, wind direction, and cloud chemistry.

The effects of acid rain include:

- Damage to buildings, monu ments, and statues.
- Destruction of lake and river ecosystems. Fish cannot reproduce and soon die out when acid levels become too high in rivers and lakes. If a lake or river loses its fish population, animals and birds in the area may starve or be forced to move away from the area to look elsewhere for food.
- High acid levels dissolve metals, such as aluminum, that are present in river and lake beds, and soil and rock aquifers. The metals enter the water and possibly contaminate fish, making them harmful for wildlife and human consumption.
- Damage to plant life. Acid rain can affect trees and crops by directly attacking their leaves and needles or by soaking into soil, and changing its chemical balance.
- Contamination of drinking water. By gradually eating away at metal pipes, acid rain causes metal to enter the drinking water supplies. Some studies have linked acid rain to increased infant mortality rates and lung dysfunctions.

Discussion:

1) *Introduce air pollution by asking the students what their senses tell them about the air. Explore how we can use our sense of sight, taste, and smell to be "air detectives."*

2) *Brainstorm sources of air pollution such as cars, factories, fires, and cigarette smoking. Discuss what common activities in their own lives indirectly contribute to acid rain (e.g., electricity demand causes power plants to create more air pollution). What can we do to reduce air pollution? Discuss ways to save energy.*

3) *Explore how difficult it is for the United States and Canada to decide how to eliminate acid rain problems and compromise. Discuss solutions to the acid rain problem and how some of the solutions may affect other important areas such as the economy, jobs, and industry. Ask if either the United States or Canada could solve the acid rain problem alone and discuss the advantages of working together. Ask students to think of other situations where they have found it was best to cooperate.*

Activities:

1) To illustrate how acid rain occurs, have the students draw a picture of industry emissions entering the sky and coming back down as rain. The hydrological cycle graphic on page 15 may be useful.

2) **Seeing Air Pollution**

Materials: Cardboard, scissors, clear sticky tape or vaseline, string, magnifying glass.

Procedure: Cut out strips of cardboard about 10 inches long and two inches wide, cut a number of holes in the strips, and tape across the holes with the sticky tape (vaseline on the cardboard strip will also work). Tie a piece of string to one end of each strip, and hang outdoors and in the classroom for one week. Collect strips and examine tape under a magnifying glass. Where do they think the dirt on the tape comes from? Which strips showed more dirt and why?

3) **The Effects of Acid**

Materials: Two copper pennies, two non-metal disposable cups, marker pen, lemon juice or lemons, tap water.

Procedures: Place one penny in each cup. Mark the cups A and B. Squeeze lemon juice over one of the pennies so that it is well covered. Add the same amount of water to the other cup (warning: liquid could be harmful if swallowed). Hypothesize what may occur if you set aside the cups for a few days. After 4-5 days, check your hypotheses. The liquid in cup A will be bluish green in color, the water in cup B remains clear. Discuss results. What do the students think made the lemon juice change color? What happens when they get lemon juice on a cut? What acids are safe to drink? What acids are not?

4) **The Incredible Terrific Cleanup Machine**

Materials: Paper, pencils, markers, or crayons, construction paper or magazines which can be cut up, scissors, glue.

Procedures: Brainstorm what a machine to clean air pollution would look like and how it would operate. Allow the students to express their ideas freely. Divide the class into groups and have them use the materials to create a machine of their own. When each group has completed their machine, let members of each group explain their creation to the entire class. Ask students what they could create if they combined all their ideas to make one Incredible Terrific Cleanup Machine. Relate this to the idea of two countries combining their resources to clean up pollution in the Great Lakes.

Environmental Sciences

Research is very important to the progress of cleaning up the Great Lakes. It is essential if we are to fully understand the effect of human activity on the environmental quality of the Lakes. Research vessels like *Lake Guardian* provide us with more information about the Lakes so we can make better decisions about how to clean them up.

This lesson, *The Journey of Lake Guardian*, is a read-aloud story. The ideas and problems can be adapted for all levels of K-5 students. Each lake is explored and the many environmental concerns facing the Great Lakes are revealed and discussed. Discussion topics and hands-on activities follow each story segment.

Part 1: The Journey of *Lake Guardian*

Story Highlights

Hot Spots:

The 42 "Areas of Concern" in the Great Lakes Basin identified by the International Joint Commission (see Social Studies lesson) where pollution problems are of concern and environmental quality standards are not being achieved.

See the inside cover introduction for more information regarding *Lake Guardian*.

Vocabulary:

adventuresome	microscope
chemicals	pollution
contamination	reagent
distilled	research
guardian	scientific
hotspots	toxic
laboratory	winches

Lake Guardian, a very curious and adventuresome research boat, is setting out to explore and learn about the Great Lakes. *Lake Guardian* loves to travel, and the Great Lakes are her favorite place to go because of their large size, beauty, and exciting history.

Lake Guardian will cruise from shore to shore visiting all five of the Great Lakes. She will stop to study the air, water, land, plants, and animals, along with other creatures that you can only see under microscopes. Learning about all the kinds of pollution in the Lakes is important because it will help make them clean and keep them beautiful. There are some kinds of pollution you can't even see and smell! Where does it come from? How much is there in each Lake? How does it hurt animals, plants, and people that live in the Great Lakes? *Lake Guardian* wants to understand it all because she is a guardian of the Great Lakes, and she wants to take care of and protect them. Many people depend on *Lake Guardian* and the things she learns about the Great Lakes, because they too are working hard to make the Lakes cleaner and healthier for everyone.

Lake Guardian carries 11 crew members and 31 scientists along with all their special scientific machines. Weighing 182 tons in the water, she is 180 feet long and 40 feet wide, so she has plenty of room to carry all the necessary equipment. *Lake Guardian*'s laboratory contains scientific instruments to measure very low levels of contamination; refrigerators and freezers to store and preserve samples; pure distilled water to make up chemical reagents; and computers to help with the analysis of samples. She even has several winches capable of lifting 5,000 pounds,

and has cranes capable of lifting heavier loads up to 30,000 pounds. Storms worry her though, for she is afraid of rocking too much and breaking all the special equipment.

Lake Guardian has a very busy schedule because there are 42 places she is worried about and must visit. These places are called "hot spots" because many of them are so polluted or toxic that some plants, animals, and fish that live there are sick. You can't swim or fish in these areas because you could get sick too. It is sad to think about the hot spots, and *Lake Guardian* is very proud to be such an important part of helping to clean them up.

Sometimes *Lake Guardian*'s work seems like play because each Lake is so special. Nature provided each Lake with many different trees, flowers, birds, fish, animals, people and other creatures in and around the shorelines. *Lake Guardian* hopes you begin to love the Lakes as much as she does as you journey with her. She hopes that after hearing her story, you'll learn many ways that you can be friends of the Great Lakes, and help to make them cleaner and healthier.

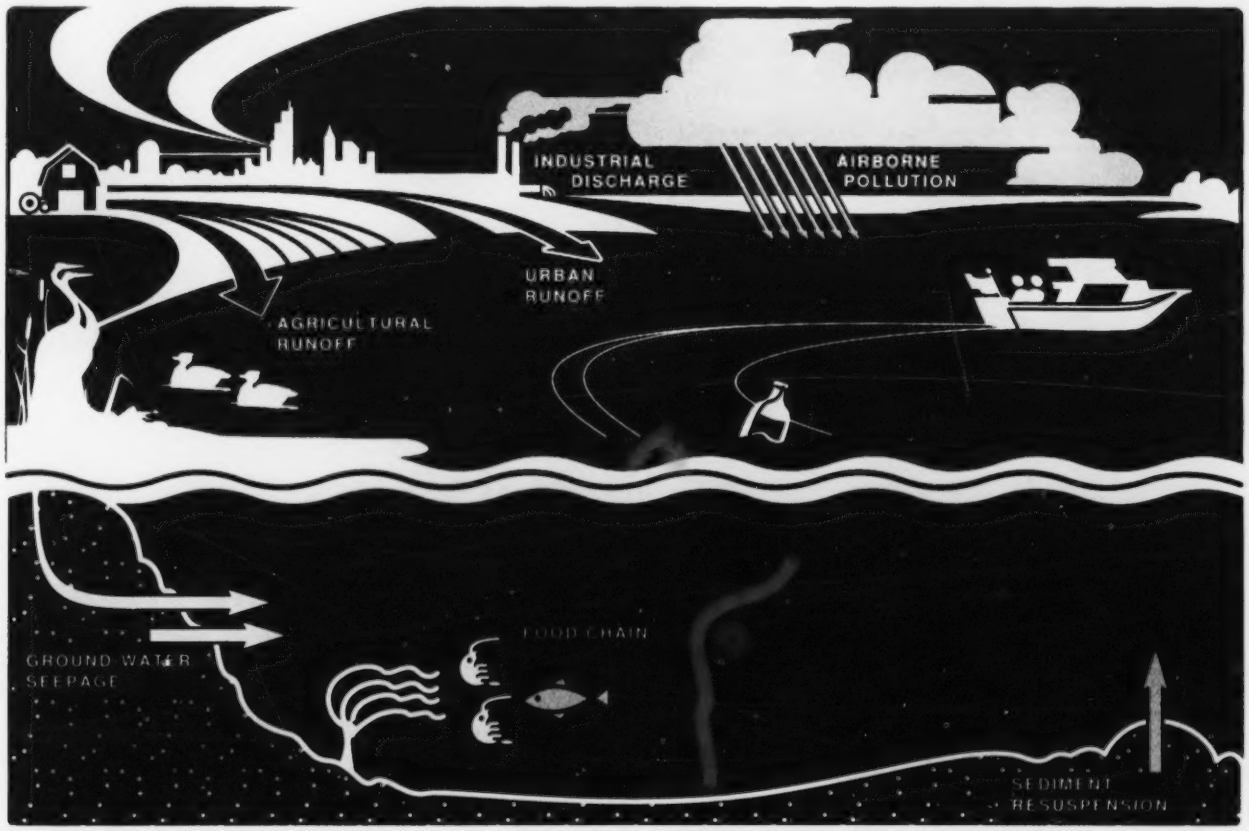
Discussion:

1) *Discuss how the students think the research boat can help the Great Lakes. Why might it be hard for Lake Guardian to study all the different kinds of pollution?*

2) *Have the students ever been in a boat? Was it as big as Lake Guardian? How big is Lake Guardian compared to the classroom?*

3) *Brainstorm types of pollution we expect to find in the Lakes. List different kinds of pollution. Do they know of types of pollution that can't be seen? What happens to pollution? What can they do to help stop pollution?*

Pollution Pathways Map



Activities:

1) On a bulletin board, display a large map of the Great Lakes, or make a copy of the Great Lakes map for each student. As a class or individually, have the students trace the pathway of *Lake Guardian* as it travels through the Great Lakes as each part of the story is read. As *Lake Guardian* arrives at each Lake, have the students fill in the name of the Lake, the names of the bordering states and provinces, the names of towns and cities mentioned in the story, and any places familiar to the students.

2) On a bulletin board or large piece of paper taped on the wall, draw a picture of a cross-section of a lake and surrounding shoreline similar to the Pollution Pathways Map on page 13 but without the figures and arrows. As the story progresses, students will discover pathways in which pollution enters the Great Lakes. Have the students draw in figures and arrows representing pathways of pollution learned from each story segment. By the final story segment, students will have learned about the many activities occurring around the Great Lakes that cause pollution problems, and will be able to see these pathways represented in their illustration.

3) Using a string on the school play yard, measure the size of the research vessel. Are the ships they have seen bigger or smaller than the new research vessel?

Part 2: *Lake Guardian* Explores Lake Superior

Story Highlights

Hydrologic Cycle:

Evaporation, transpiration, condensation, precipitation, infiltration, and runoff.

Recreational Activity is a Source of Pollution:

Environmental damage can be caused by many recreational activities. Campers, hikers, and boaters create problems by littering, dumping sewage and other wastes into the lakes, or letting gas from boats leak into the waters. Soil erosion problems result from removal of trees and grasses for development of marinas and summer homes.

Hot Spots: 8

Peninsula Harbour, Jackfish Bay, Nipigon Bay, Thunder Bay, St. Louis River, Torch Lake, Deer Lake/Carp Creek/Carp River, St. Marys River.

Vocabulary:

anchor	ocean
coastline	precipitation
condensation	recreation
creek	runoff
evaporation	serene
expanse	stream
ferocious	transpiration
hydrologic cycle	trout
infiltration	Wayzhigwanaad

Lake Guardian was excited to start her journey in Lake Superior, the largest of all the Great Lakes and the one with the least amount of pollution. Lake Superior is so large and deep that all the other Great Lakes plus three more lakes the size of Lake Erie could fit in it. It is well-known for its lovely beaches and clear blue water. The water is so clear you can see fish swimming way down deep. *Lake Guardian* knew she needed to be careful, for Lake Superior's mood can be so peaceful and serene one minute, and the next minute a ferocious and lashing storm will rise out of its depths.

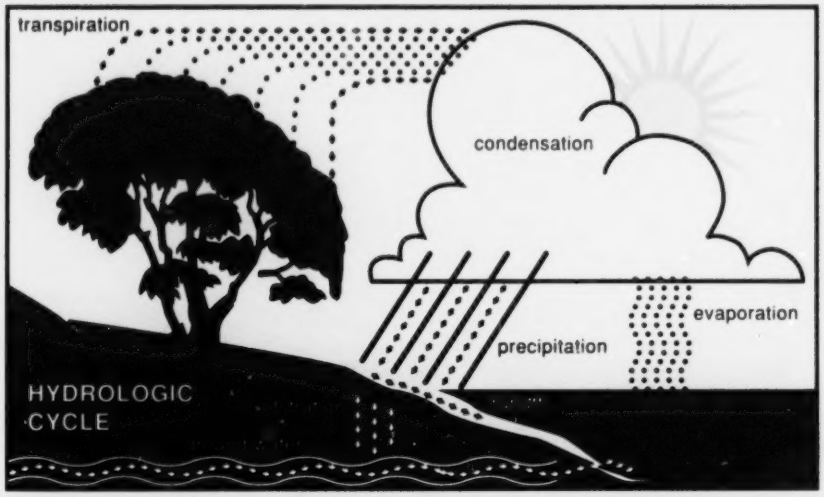
Lake Guardian started in the town of Duluth, Minnesota, and headed northeast towards Thunder Bay, Canada. As she cruised, *Lake Guardian* learned that very few people live around this Lake area compared to the rest of the Great Lakes, and she knew that this was a large part of why Lake Superior is so beautiful and clean. The more people there are in an area, the more pollution problems *Lake Guardian* knew she'd find. How did she know this?

The vast expanse of water and many pretty hills around Lake Superior would make it hard for *Lake Guardian* to leave. As *Lake Guardian* cruised towards Thunder Bay, she saw people hiking, swimming, fishing, skiing and boating. Then she looked over and was so shocked she almost dropped her anchor! As a motor boat passed her bow she watched a family toss a six-ring plastic can holder overboard with a plastic grocery bag. *Lake Guardian* was very upset because beautiful birds can get their beaks or heads caught in the rings, and then they can't eat. She was concerned that the fuel from the motor boats was polluting the water too. People often forget that when they have fun, they need to be careful that they don't harm nature. *Lake Guardian* wished all people had respect for the Great Lakes like the Chippewa culture does. In the Chippewa language the word "Wayzhigwanaad" means "water spirit," and they emphasize that the health of our water is directly

related to the quality of life for all living things on this planet. *Lake Guardian* looked forward to sharing the Chippewa spirit of caring for the Great Lakes with everyone she met on her trip.

Lake Guardian collected some samples of water to study how much fuel spills from the motorboats and freighters into the water. As she passed by Thunder Bay she saw big paper mills and large fishing boats. Crossing over to Marquette, Michigan, she followed the coastline towards Sault Ste. Marie, where she would travel to get to Lake Huron. The Lake is so big that sometimes *Lake Guardian* thought she was in an ocean. "Where did all this water come from?" *Lake Guardian* asked the scientists on board. Dave the environmental scientist told her about the pathways of water on Earth, called the hydrologic cycle. Dave told her that rain helps keep the Great Lakes full. The rain that falls on the land either runs off the surface back into the Lakes through streams and creeks, or soaks into the ground. As she was talking to Dave, a speckled trout swam by. *Lake Guardian* asked the trout if he knew how water in the ground finds its way back to the Lakes. The trout explained that the water travels underground and enters creeks and streams which drain into the Lakes, and sometimes enters the Lakes directly below the surface. Dave then added that when it is hot, water evaporates up into the air. When the water gets high enough in the air, it cools off and comes back down as rain and the cycle starts all over again.

"*Lake Guardian*, it will be important for you to understand how water finds its way to the Great Lakes, because pollution sometimes follows the same paths to enter the lakes and hurts them," Dave explained. *Lake Guardian* thought a lot about what Dave said, and quickly began collecting samples of water and fish to study. She wanted to see what kinds of pollution were already using some of those pathways into Lake Superior.



Discussion:

1) *Explain the hydrologic cycle to students (see diagram). Have they seen evidence of the cycle in their daily lives? When they wash the dishes or take a bath or shower, what happens to the steam? Relate this to condensation, precipitation and runoff in the hydrologic cycle.*

2) *Explore why areas of higher population result in more pollution in the Great Lakes. Discuss which of the Great Lakes they would prefer to live beside and why. Discuss how recreation and tourism may result in harm to the Lakes. What should they do if they see someone litter at a beach or picnic?*

Activities:

1) Have the students do the Great Lakes map activities. On the Pollution Pathways Map draw in figures representing recreational activities.

2) **Fun Without Pollution**

Have the students create a "Fun Without Pollution" booklet for their family or school's next outing. As a class or individually, have the students decide on pollution prevention rules for their family or school to follow during recreational activities. Include topics such as using garbage cans and preventing fires. On each page write out the rules with drawings illustrating the rules. Magazines can be used for cut-outs, and younger children can illustrate their ideas rather than writing them out. Staple or tie the pages together to make a booklet.

Part 3: Investigating Lake Huron

Story Highlights

Airborne Pollution:

Atmospheric toxic pollution is a major source of contaminants for the Great Lakes ecosystem. At least 40,000 chemicals are used by U.S. industry. As an example, Lake Superior currently receives 840 kilograms per year of Polychlorinated Biphenyls (PCBs) – a carcinogenic chemical compound – from the atmosphere, and account for 93% of the current total load of PCBs in the Lake. Pesticides are thought to come from as far away as Central America are found in the Great Lakes.

Biomagnification:

The process of increasing concentrations of contaminants through the food chain. Persistent chemicals which do not break down readily in the environment accumulate in organisms and become concentrated at levels much higher than in the open water. The top predators at the end of the food chain may accumulate concentrations of chemicals toxic enough to result in serious deformities or death.

Wetlands:

Natural water-holding shallow areas such as bogs, marshes, or swamps provide food, shelter, and water for plants and animals that need a watery home. Wetlands provide shelter for young fish, provide flood control and sources of recreation, and help clean water as it travels slowly through. Common animals and plants found in wetlands include the great blue heron, frogs, raccoons, cattails, dragonflies, crayfish, willow trees, red-winged blackbirds, northern pike, turtles, muskrats, and water lilies.

Hot Spots: 5

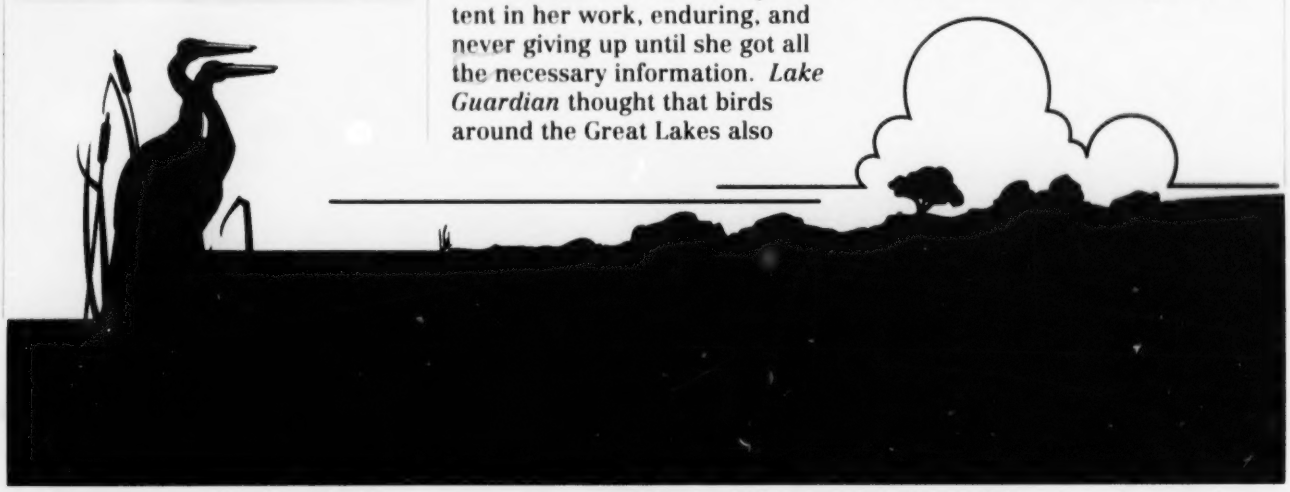
Saginaw River/Saginaw Bay, Collingwood Harbour, Penetang Bay to Sturgeon Bay, Spanish River Mouth, St. Clair River.

Vocabulary:

airborne pollution	predator
biomagnification	restore
cormorant	scavenger
critters	sediment
endangered species	Sweetwater Seas
herring gull	persistent
phytoplankton	wetlands
	zooplankton

Part of *Lake Guardian*'s job is to collect samples of air to make sure it is clean enough for animals and people to breath. She had to make sure she was persistent in her work, enduring, and never giving up until she got all the necessary information. *Lake Guardian* thought that birds around the Great Lakes also could help her find out how clean the air is. She decided to cruise up through the Georgian Bay to the Parry Sound and ask a herring gull. Herring gulls are common around the Great Lakes. "Herring Gull, does the smoke and dirt from big factories and machines around the Great Lakes bother you? Do you think it makes the Great Lakes unhealthy?"

"Oh my yes. After it rains, do you know why the air smells so fresh and clear? That's because the water is cleaning the air when it falls, and takes the pollution right out of the sky. It is wonderful for flying afterwards, but you must understand that the smoke and pollution falls with the rain into lakes and on the land. When the pollution falls to the bottom of a lake, small creatures eat it in the mud called sediment. Fish eat these small creatures in great numbers, and the fish may get very sick from the pollution inside the small creatures. I am a scavenger and I love to eat the remains of fish and food that fishermen toss overboard, and my friends the cormorants like to eat fish where they live by the shores. We end up eating the polluted fish, but there is nothing else for

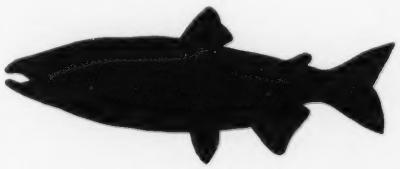


me to eat, and I can't tell the difference between a good fish and a poisoned fish. Some of my eggs don't hatch and my babies have been very sick because they have been affected by the pollution I eat in the fish. It makes me very sad."

Herring Gull's story helped *Lake Guardian* understand how animals depend on each other for food. She also learned how pollution eaten by one animal can eventually affect many other animals. *Lake Guardian* collected many samples of small creatures, fish, and microscopic plants and animals such as phytoplankton and zooplankton from the bottom of Lake Huron to study how much pollution these critters ate.

Lake Guardian's conversation with Herring Gull made her want to know more about how air pollution affects other animals, so she decided to head west to Cheboygan, Michigan. Just south of Cheboygan was a marshy and swampy area called a wetland, where *Lake Guardian* would find many of Herring Gull's friends, the Cormorants. Cormorants are very good divers and swimmers, and eat a lot of fish. The cormorants confirmed what Herring Gull had told her, and explained that their babies often don't live because of the pollution. The cormorants said that many other animals get sick from the pollution too. *Lake Guardian* learned that wetlands are too soggy for people to live in, but they are just right for many animals. Wetlands provide homes for many endangered species, but pollution was affecting these animals too. Although the stories made *Lake Guardian* very sad, she was glad to take samples of water, plants, and sediment to learn about how pollution from the air affects them. The information she collected would help people find ways to protect and restore the wetlands, and all the other creatures living in the Great Lakes Basin.

As she cruised along, she couldn't help thinking about how beautiful Lake Huron was, and she could understand why the first English name the Great Lakes were given was "Sweetwater Seas." Before leaving Lake Huron for Lake Michigan, *Lake Guardian* made sure she picked up a good supply of navy beans for making delicious soup throughout the voyage. Did you know that the Lake Huron area produces more dry beans than anywhere else in the United States?



Activities:

1) Have the students do the Great Lakes map activities. On the Pollution Pathways Map draw in figures representing sources of air pollution.

2) **Biomagnification and the Foodchain**

Materials: Depending on the size of the class, make the equivalent of six circles per student out of blue paper, marking 1/3 of them on one side with an "X."

Procedure: This activity can be acted out or if desired, conducted as a discussion through diagrams on the board. Identify one student as the herring gull who likes to eat fish and have him or her stand at one end of the classroom. Divide the remaining students into increasingly larger groups representing the links of the food chain: large lake trout, smaller rainbow smelt, zooplankton, and microscopic phytoplankton. The majority of students should be phytoplankton. Place the blue disks on the floor with those marked with an "X" face down. The blue disks represent water which phytoplankton take in to obtain nutrients to live. Those disks marked with an "X" contain pollution which has entered the water through the air. Have the phytoplankton "feed" by having them pick up the disks. Once all the disks are gone, have the phytoplankton reveal who has consumed pollution. Have the zooplankton "feed" on phytoplankton by dividing the phytoplankton up evenly among the zooplankton. Repeat these steps with rainbow smelt and lake trout. When it comes to the herring gull eating his or her dinner, how much pollution has accumulated through the foodchain?

Discussion:

1) *Relate the story's discussion of pollution eaten by small creatures to the food chain, reaching through the food chain to the fish that humans eat. Follow the pollution from a paper mill smokestack all the way to their own dinner plate.*

2) *Talk about wetlands. Have the students ever seen one? Why are wetlands important? Discuss what an endangered species is.*

Part 4: The Journey Continues on Lake Michigan

Story Highlights

Surface Runoff:
Surface runoff is a significant source of pollution in the Great Lakes. It is a pathway for a wide variety of pollutants to enter lakes. Agricultural runoff includes pesticides and nutrients; urban surface runoff includes oils, greases, salt (from winter road clearing), and litter.

Ground water:
Ground water is water below the surface of the earth. Ground water is our storage of drinking water. It replenishes the Great Lakes, which is why it is so important to the Great Lakes ecosystem. As water passes through subsurface areas, some substances are filtered out, but others dissolve in the water or are carried by the water. This can include human-made materials that have infiltrated into the ground or have been buried in dumps or landfill sites. The movement of ground water is a major pathway for pollution to reach the Great Lakes.

Hot Spots: 10
Manistique River, Menominee River, Fox River/Southern Green Bay, Sheboygan, Milwaukee Estuary, Waukegan Harbor, Grand Calumet River/Indiana Harbor Canal, Kalamazoo River, Muskegon Lake, White Lake.

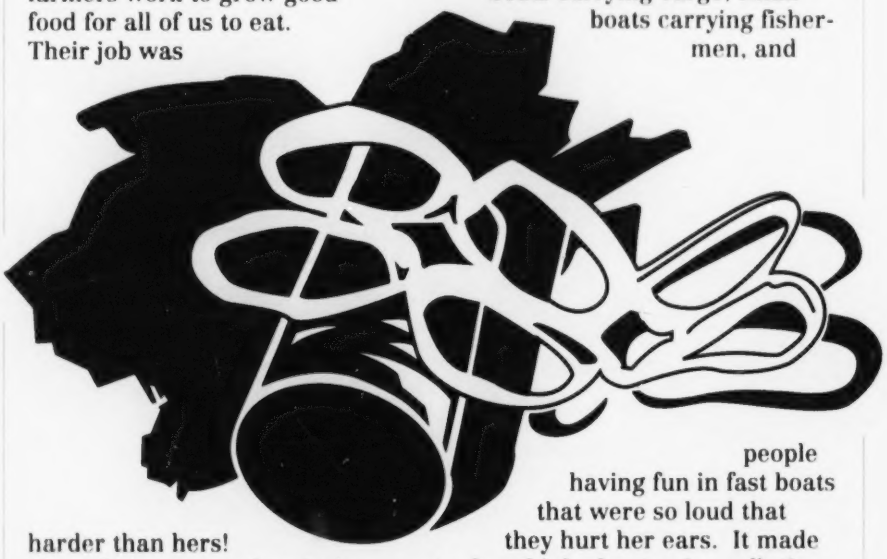
Vocabulary:

agriculture	runoff
cargo	sewers
chemicals	smelt
ground water	treatment plant
noise pollution	urban
pesticides	wastewater

Lake Guardian was so happy to reach Lake Michigan, the third largest lake in the Great Lakes. This area had the most farmland of all the other Lakes, and *Lake Guardian* had heard many stories about the tasty cherries of Michigan and dairy products of Wisconsin. *Lake Guardian* loves cherries, and since three-quarters of our nation's tart cherries are grown in Michigan, she headed straight down the Michigan coastline, passing Ludington, Muskegon and Benton Harbor. Dave the environmental scientist had made *Lake Guardian* promise that she'd stop so he could have a piece of cherry pie, and then head over to Wisconsin's dairy farms to get a slice of cheddar cheese and a glass of milk to go with it.

All the news that *Lake Guardian* learned about the Lake Michigan area was not good, though. She learned how hard farmers work to grow good food for all of us to eat. Their job was harder than hers! Many farmers use chemicals to fight off insects and weeds and to help their crops grow better, but some chemicals can later become pollution problems for the Great Lakes. *Lake Guardian* cruised along the shore and watched how the rain washed the chemicals off the land and carried them into the Lake. She was worried that these chemicals may hurt her friends in the wetlands, so she stopped to collect many samples of water and sediment to find out how much pollution was coming from the farms and if it was harming plants and animals. *Lake Guardian* also watched how the wind carried off some of the chemicals that a farmer was spraying on his fruit trees.

Cruising to the south end of Lake Michigan, *Lake Guardian* came to the big city areas. It was exciting to ride by Gary, Indiana where the mills were busy making steel, but she worried about where the wind would take all the smoke rising out of the smokestacks. When *Lake Guardian* arrived at Chicago, she couldn't believe how many boats there were everywhere! Big boats carrying cargo, small boats carrying fishermen, and people having fun in fast boats that were so loud that they hurt her ears. It made her think about noise pollution too, and how the noise must scare the birds and animals that live around the Lakes. *Lake Guardian* thought about all the fuel that must be going into the water from these boats, and she decided that her favorite boats



were the clean and beautiful sailboats that relied only on the wind to make them move.

So far, *Lake Guardian* had not been to an area with cities as big as Chicago. One of the first things that she noticed was the big difference in the color of the water. She remembered how clear and blue Lake Superior was, and when she looked at the water at the edge of Chicago, she couldn't see through it at all. She talked to some local fish and asked them what they knew about pollution near the big city. Rainbow Smelt told her stories similar to Herring Gull. "Most people love how the rain clears the air and washes the streets, but we fish sure don't. Living next to a large city means that a lot of litter and dirt washes or blows off the streets and into the Lake. Most people don't realize where that gum wrapper or cigarette is going to go if they just throw it on the ground. It makes me very sad. Rainwater also washes down the city sewers, and that is good because it goes to a special machine, called a wastewater treatment plant, that cleans it up first. But sometimes if it rains really hard, the sewers overflow, causing the dirty water to overflow straight into the Lake." After listening to Rainbow Smelt, *Lake Guardian* carefully gathered samples of water, fish, plants, and mud from the shorelines of Chicago, Waukegan, Sheboygan, and other cities on Lake Michigan. She had to travel quickly, for it was a long way to Lake Erie. She had to travel back through Lake Huron to get there.

Activities:

1) Have the students do the Great Lakes map activities. On the Pollution Pathways Map draw in figures representing sources of agricultural and urban pollution runoff and infiltration to groundwater.

2) **Mingle Mingle**

Materials: A clear bottle with a top, water, oil, food coloring.

Procedure: Put quantities of water and oil in the bottle and close it. Use motor oil or vegetable oil with a drop of food coloring added if you prefer. The separation of oil and water should be easily observed. Shake the bottle to try to get the oil and water to mix and then let it sit and see what happens. Relate the oil in the experiment to urban surface runoff discussed in the story. Talk about what this oil would do to animals, and what effects it may have on plants or creatures living below the surface of the oil, which blocks sunlight.

3) **Pollution Underground**

Materials: Large flat plastic planting tray; gravel; sand; water pitcher; cooking oil; food coloring; pancake syrup; onion slices; and liquid soap.

Procedure: Ahead of time, cover a corner of the tray with a layer of gravel. Place drops of food coloring, onion slices, and a few tablespoons of pancake syrup, cooking oil, and liquid soap on top of the gravel. Cover these materials with a thick layer of sand. In front of the students, pour water into the mound of sand, gravel, and other materials, and let water run into empty portion of the tray. Collect water and have students determine what materials are present in the water; how they entered the water; and what substance moved these materials from the soil to the water. Relate this activity to how agricultural and urban litter and pollution on and in the ground can contaminate ground water and ultimately affect the quality of the Great Lakes.

Discussion:

1) *Talk about the new pollution pathways discussed in the story. Explore experiences the students have had related to the pathways.* ***Rural:*** *Have they ever seen a farmer fertilize or spray pesticides on crops? Could they smell it? How do they respond to the farmer's dilemma of using fertilizers and pesticides?* ***Urban:*** *Ask the students for examples of trash or abandoned things they see every day on the street. What activities at home result in pouring or dumping things on the ground outside, and how might these materials reach the Great Lakes? (see Activity #3) Does the story make them think twice about what they throw on the ground?*

2) *Ask if any of the students have ever had fruits or vegetables they think may have come from the Lake Michigan area. Have them ask the grocer where they get fruits and vegetables to see if any come from these areas.*

Part 5: *Lake Guardian* Travels the Length of Lake Erie

Story Highlights

Mayflies:

Mayflies are excellent indicators of water quality because they are not tolerant of pollution. Monitoring programs in some Great Lakes states use mayflies as one of several indicators of pollution-free water.

Mayflies are aquatic insects with six legs and three body parts typical of insects, as well as two short antennae. Females deposit their eggs into clear running streams and lakes singly or in strings, depending upon the species.

Nymphs hatch from the eggs and remain in shallow water or burrow beneath the mud and gravel, feeding upon aquatic plants. When ready to leave the water, they swim to the surface and molt, emerging in adult form. At this point, they are called "duns" and are not yet sexually mature. They crawl onto nearby vegetation and wait from several hours to a few days for a final shedding of the exoskeleton and emerge as full-fledged adults. On a still sunny day, males wing upward and float down over and over again. Females join the swarm and find a mate and lay eggs in the water, beginning the cycle anew.

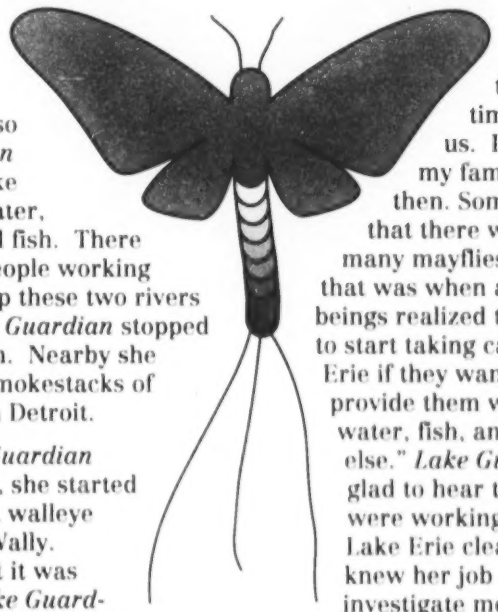
Hot Spots: 11

Clinton River, Rouge River, River Raisin, Maumee River, Black River, Cuyahoga River, Ashtabula River, Wheatley River, Buffalo River, Detroit River, Niagara River.

Vocabulary:

exoskeleton	monitor
factory	nymph
hot water emissions	oxygen
industry	steel
mayfly	walleye pike

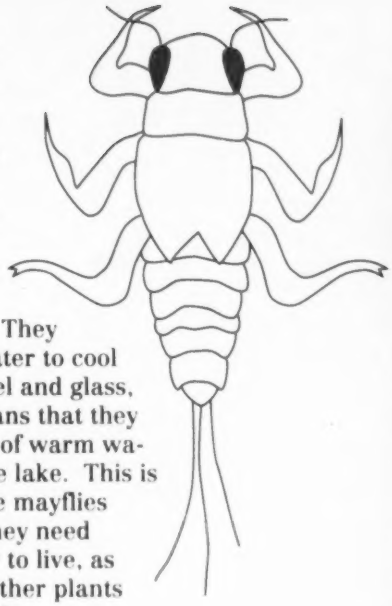
Lake Guardian made her way back past Mackinac City and turned south. She travelled on Lake Huron past Alpena and on through the St. Clair River towards Lake Erie. Her studies had shown that the dirtiest areas of the Great Lakes were the riverways that lead into the Great Lakes. The St. Clair and Detroit Rivers were two of them, so *Lake Guardian* stopped to take samples of water, sediment, and fish. There were other people working on cleaning up these two rivers too, and *Lake Guardian* stopped to watch them. Nearby she saw the big smokestacks of car makers in Detroit.



As *Lake Guardian* cruised along, she started talking with a walleye pike named Wally. Wally thought it was great that *Lake Guardian* was working so hard to gather information to help keep the Great Lakes clean. He asked *Lake Guardian* if she was going to talk with the mayflies. *Lake Guardian* didn't know what a mayfly was. "You have to meet the mayflies," exclaimed Wally. "They're famous! Mayflies are insects that live in the water, and they do not like water pollution at all. If you find mayflies, you know the water must be clean and healthy because mayflies just can't live there unless it is. Their homes must be cool with lots of oxygen." Wally told her how scientists keep track of how many mayflies there are because it helps them know whether the water is clean or not. Many schools and their students volunteer to count mayflies in streams, creeks, and lakes near their homes to help. When the number of mayflies gets too low, it tells the scientists that there may be a problem with too much pollution in the water. Wally explained, "Mayflies are famous in Lake Erie because they let everyone know that Lake Erie was very sick in the 1970s. Boy, was that a bad time for all of us. I lost a lot of my family back then. Someone noticed that there weren't very many mayflies left, and that was when all the human beings realized that they had to start taking care of Lake Erie if they wanted it to provide them with good water, fish, and everything else." *Lake Guardian* was glad to hear that people were working to keep Lake Erie clean, but she knew her job was to investigate more.

Lake Guardian decided to continue her journey around Lake Erie on the southern shore, starting with Toledo, Ohio. Toledo was famous for the beautiful glass that was made there. Even though the glass was beautiful, it still was a concern of *Lake Guardian*'s. She stopped to count the mayflies and study how much pollution was being given off by the big glass factories. She continued on to Cleveland, where there are lots of factories making steel and cars. *Lake Guardian* wanted to look for mayflies here too. Wally explained that industries like the ones making steel,

cars, and glass get very hot when they melt the glass and steel to make cars and windows. They use the water to cool off the steel and glass, which means that they let off lots of warm water into the lake. This is bad for the mayflies because they need cool water to live, as do many other plants and animals.



Lake Guardian crossed the Lake to look at the beautiful northern shore of Lake Erie and its farmlands. Lots of sheep and lambs are raised in Canada near Lake Erie, and *Lake Guardian* wanted to visit them before she made her way to Lake Ontario.

Discussion:

1) *Have the students do the Great Lakes map activities. On the Pollution Pathways Map draw in figures representing sources of industrial hot water emissions.*

2) *Review with students why the mayfly is important. Can they think of other indicators of pollution? (Water discoloration, smelly air, lack of fish and birds)*

3) *Discuss how industrial or municipal warm water discharge can be bad for lakes. Emphasize how human activity can harm the Great Lakes and not necessarily involve pollutants. Can the class think of other examples? (erosion from shoreline development)*

Activities:

1) Draw and discuss the life cycle of the mayfly on the board. Have the students conduct research of other aquatic insects and report to the class why they think they are important.

2) Plan a field trip to nearby streams or creeks to conduct water quality monitoring activities including mayfly counting and trash collection. Discuss topics such as the difference between ground water and surface water.

3) To highlight the importance of monitoring our environment, have the students monitor and chart your school or their family's generation of waste. Have a custodian of the school give the class a tour of how all the different kinds of waste are handled at the school, such as waste paper and cafeteria garbage. Does the school recycle? Choose "monitors" from the class and for two weeks, have a monitor visit the custodial office each day and report back to the class on how much waste was generated each day. Keep track of the reports and have the students discuss ways the school or their families can minimize waste.

Part 6: The End of the Journey, Lake Ontario!

Story Highlights

Industrial Runoff:

Many chemical substances entering the Great Lakes from industrial use do not dissolve easily in water. These include heavy metals and organic compounds like PCBs. Since they do not dissolve well in the water, they settle on the bottom of the lakes in sediments.

Sediment Pollution:

When polluted sediments are stirred up, the pollutants are eaten by bottom feeding organisms and become part of the food chain, concentrating through the food chain through biomagnification, discussed in Part III of the story. Sediment is stirred up three ways: when the lake bottom is removed to make a lake deeper for large boats (called dredging); by waves from storms or human activities like boating; or when animals living on or near the bottom stir it up looking for food or to use the sediment for shelter. Contaminated sediments cause the most problems when they are stirred up because the pollution spreads.

Hot Spots: 8

Eighteen Mile Creek, Rochester Embayment, Oswego River, Bay of Quinte, Port Hope, Toronto Waterfront, Hamilton Harbour, St. Lawrence River.

Vocabulary:

algae
algae bloom
bacteria
carp
dissolve
dredging
ecosystem
industrial runoff
nitrogen
potassium
sediment pollution
sludge worms
solution
species
tolerate

Lake Guardian was nervous as she left Lake Erie, for she thought that she might take a wrong turn and go over Niagara Falls! She was big and strong, but no boat could survive a ride like that. She was relieved to find the Welland Canal and make her way to beautiful Lake Ontario. She had heard so much about the falls, and the breath-taking Thousand Islands on the

east end.

Lake Guardian got out her map to trace her journey. She was very interested in looking at how all the water in the Lakes eventually comes through Lake Ontario because it is the last Lake before the water heads out the St. Lawrence River and into the ocean. This means that a lot of the dissolved substances and pollution she studied in the other Great Lakes also has journeyed to Lake Ontario, which is one of the reasons why Lake Ontario is the most polluted of all the Great Lakes. *Lake Guardian* knew that another reason was its small size. It doesn't have as much water to spread out the pollution.

Lake Guardian traveled first by Hamilton and Toronto, Canada, passing lots of big industrial factories and buildings. She remembered all the factories and big machines she had seen along the shores of all the other Great Lakes. *Lake Guardian* was concerned about more than the smokestacks and air pollution she had learned about. She was worried about chemicals dumped by the factories and businesses into the water. *Lake Guardian* thought about Herring Gull's friends the cormorants, and what she learned in Lake Michigan about the chemicals from farms running off into the water and settling to the bottom for small creatures to eat. She knew that this was happening with the chemicals from factories and businesses too.

She asked Dave the environmental scientist if there were other effects from these chemicals on the Great Lakes besides polluting sediments and entering the food chain. Dave described how some chemicals, such as nitrogen and potassium, from industry, farms, and city areas are like food to green plants in the water, including algae. "The algae grow very big very fast, and we call it an algae bloom. It eventually dies," Dave explained," but when it does, the bacteria that feeds on the dead algae takes a lot of the water's oxygen. The more algae that blooms and dies, the more bacteria there is taking oxygen from the water." *Lake Guardian* knew that without oxygen, many species of fish could not live. Dave explained that when a lake's oxygen levels are lowered, some species die out—mayflies included—and others like sludge worms and carp, that can tolerate low levels of oxygen, move in. That's why scientists look for changes in the kinds of animals living in the Great Lakes. It tells them if too many chemicals are changing oxygen levels and upsetting the balance of animals and nature, called the ecosystem.

Lake Guardian got to work and collected samples and looked for algae blooms all along the shoreline of Lake Ontario. She examined the different species to see if she could tell if chemicals were changing the water's oxygen levels too much.

By the end of the journey, *Lake Guardian* had learned a lot about the beautiful Great Lakes. She wanted to tell everyone about all that she had learned. What could people do to help the Great Lakes? She was concerned about the many pollution problems that she saw, but she knew that things could get better. *Lake Guardian* knew that by helping to collect samples and learning more about the Lakes, she was part of the solution. That made her feel proud as she journeyed up the St. Lawrence River to peek at the ocean before heading back home.

Discussion:

1) *Research the kinds of animals that live in the sediment at the bottom of a lake. Have the students ever seen a crawfish or a fresh water mussel? Have they ever eaten one?*

2) *Ask the students what they think happens to sediment that is polluted? Where does the pollution go from there?*

3) *Discuss how the students can be a good friend of the Great Lakes. How can they or their families be part of the solution?*

Activities:

1) Have the students do the Great Lakes map activities. On the Pollution Pathways Map draw in figures representing sources of industrial waste discharge.

2) **Sediment Experiment**

Materials: Deep plastic container (rectangular—at least 12" x 12" x 4" deep), fine sand, coarse sand, tiny colored plastic beads, plastic spoon.

Procedure: Ahead of time, put a one-inch layer of fine sand into the plastic container. Provide every group of students with a container. Mix the beads with the sand, representing pollutants. Cover with water until the water level rises one inch above the sand layer. Allow this to sit until the water is clear. Carefully drag the end of a pencil once across the top of the fine sand. This represents how the sediment might be stirred up by organisms living on or near the bottom, or by wave action from storms or boats. Use the plastic spoon, scoop up some of the sand off the bottom of the container. This is similar to the dredging of sediment. What happened to the sediment and the colored plastic bead "pollutants?"

Great Lakes Facts

General Information:

How to remember the Great Lakes' names: Remember the word **"HOMES"**

H = Huron
O = Ontario
M = Michigan
E = Erie
S = Superior

Size: Largest supply of freshwater on earth; 20% of earth's total freshwater
9,402 miles of shoreline
94,710 total square miles of surface area (about the size of Texas)

Basin: The 295,200 square mile area within which all surface water drains into the Great Lakes. Includes parts of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, Ontario, and Quebec

Lake Superior

Largest of the Great Lakes by surface area and volume, rich in natural resources, supplying the United States with 97% of its iron ore.

Surface Area: 31,700 square miles

Volume: 2,934 cubic miles

Shoreline Length: 2,726 miles (including islands)

Population: 474,150 (United States)
155,675 (Canada)

Land Use:

91% Forest
3 % Agricultural
1% Residential/Industrial
5% Other

Lake Huron

Second largest Great Lake with the longest shoreline, counting 30,000 islands.

Surface Area: 22,973 square miles

Volume: 850 cubic miles

Shoreline Length: 3,827 miles, including islands

Population: 1,606,518 (United States)
941,300 (Canada)

Land Use:

68% Forest
27% Agriculture
2% Residential/Industrial
3% Other

Lake Michigan

Third largest Great Lake. Sparsely populated and covered with forests in the northern part, and heavily populated with intensive industrial and agricultural activity in the southern part.

Surface Area: 22,278 square miles

Volume: 1,180 cubic miles

Shoreline Length: 1,659 miles, including islands

Population: 8,709,907*
*Does not include approximately 5 million residents of Chicago area who depend on Lake Michigan for water but do not live in the Lake Michigan drainage basin.

Land Use:

41% Forest
44% Agriculture
9% Residential/Industrial
6% Other

Lake Erie

Fourth largest Great Lake, shallowest and warmest, with extensive industrial development along its shores. Ninety-five percent of Lake Erie's total inflow of water comes from all the "Upper Lakes" through the Detroit River.

Surface Area: 9,906 square miles

Volume: 116 cubic miles

Shoreline Length: 871 miles, including islands

Population: 9,183,347 (United States)
1,742,805 (Canada)

Land Use:

21% Forest
67% Agriculture
10% Residential/Industrial
2% Other

Lake Ontario

The smallest of the Great Lakes in surface area, largely rural with scenic resort areas, yet contains Canada's leading commercial, industrial, and population center.

Surface Area: 7,340 square miles

Volume: 393 cubic miles
Shoreline Length: 726 miles, including islands

Population: 2,657,432 (United States)
4,616,070 (Canada)

Land Use:

49% Forest
39% Agriculture
7% Residential/Industrial
5% Other

Resources Used in Creating *Great Minds? Great Lakes!:*

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Co-operative Games for People Who Love to Play, Public Focus, guide book, all ages, (416) 967-5211.

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Directory of Great Lakes Educational Materials, Great Lakes Science Advisory Board, International Joint Commission, (313) 226-2170.

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Paddle to the Sea, Holling Clancy Holling, Houghton Mifflin Company, 1969. (Free rental of VHS video available from U.S. Fish and Wildlife Service (612) 725-3582.)

Wetlands Are Wonderful, Illinois, Indiana Sea Grant Program, teacher resource, all ages, (217) 333-9448.

Places to Write:

Center for Environmental Information
99 Court Street, Rochester, NY 14608 (716) 546-3796

Center for the Great Lakes
435 North Michigan Avenue, Suite 1408, Chicago, IL 60611 (312) 645-0901

Environment Canada
Great Lakes Environment Program, 25 St. Clair Avenue E. Toronto, ON M4T 1M2 (416) 973-6467

Great Lakes Historical Society
480 Main Street, Vermilion, OH 44089 (216) 967-3467

International Joint Commission
Great Lakes Regional Office, P.O. Box 32869, Detroit, MI 48232 (313) 226-2170

Lake Michigan Federation
59 E. Van Buren, Suite 2215, Chicago, Illinois 60605 (312) 939-0838

National Wildlife Federation
Great Lakes Natural Resource Center
802 Monroe, Ann Arbor, MI 48104 (313) 769-3351

United States Environmental Protection Agency
Great Lakes National Program Office
230 South Dearborn Street, Chicago, IL 60604
1-800-621-8431 (from IN, MI, MN, OH, WI)
1-800-572-2515 (from IL)
1-312-353-2072 (from NY and PA)

Places to Visit:

To find out more about the maritime museum in your area, contact the Manitowoc Maritime Museum in Wisconsin at (414) 684-0218.